Centre for Energy and Environmental Markets

UNSW THE UNIVERSITY OF NEW SOUTH WALES SYDNEY • AUSTRALIA

Technology Assessment for Clean Coal Technologies

Clean Coal, Brisbane, August 2005

Presented by
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The question.. and a possible answer up front

- *The question*

  What role might Clean Coal options actually play in a sustainable Australian energy future

- *And CEEM's view on the answer*

  We don't know yet!
  - … and we need a process to find out that reduces risks and maximises opportunities through support for a *portfolio* of technology options guided by a risk-based technology assessment framework
  - supported by a coherent innovation strategy
  - integrated within wider energy + climate policy framework

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Q - What is Clean Coal?

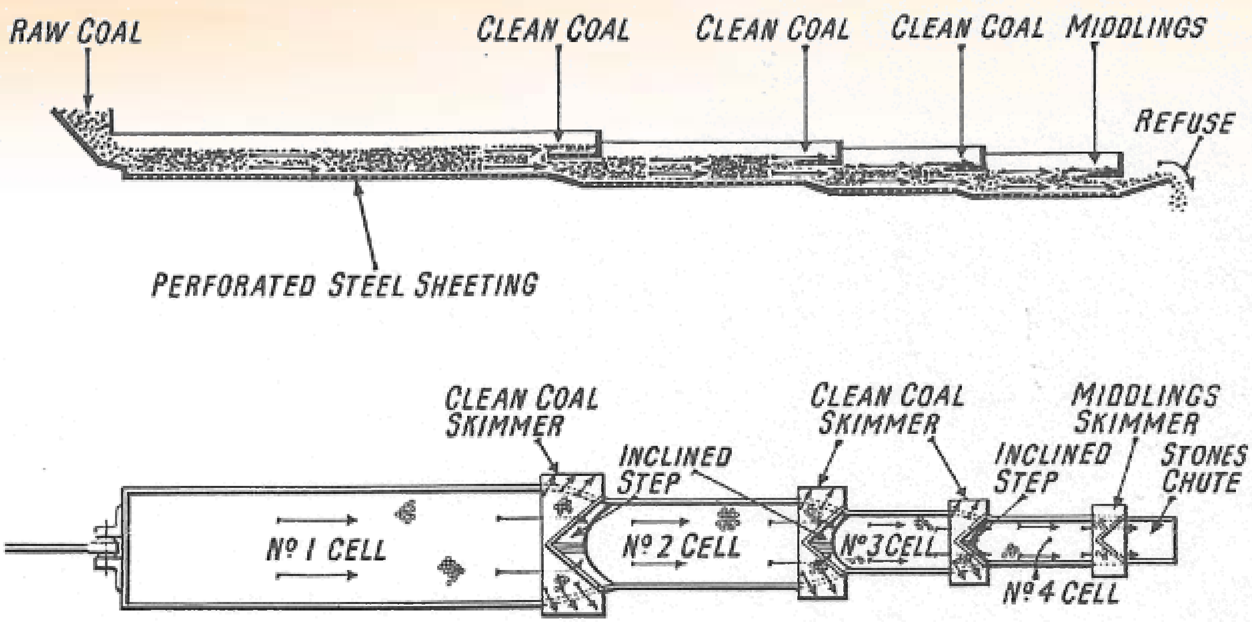
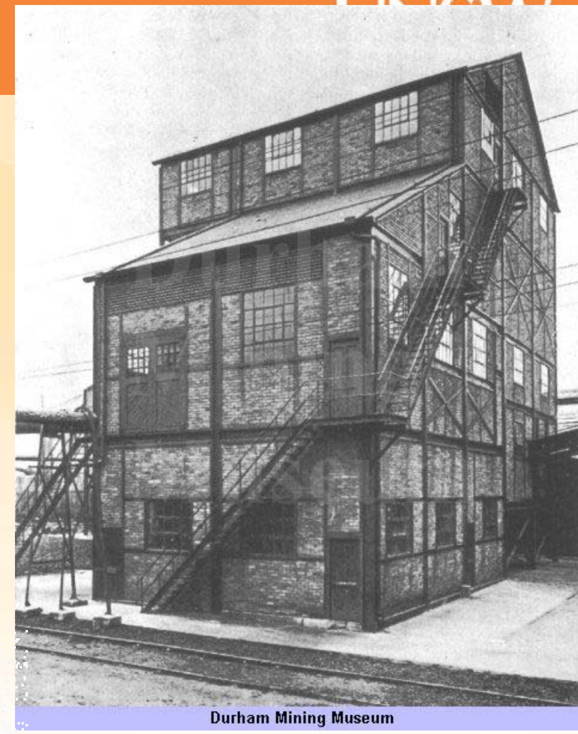


Fig. 2—Illustrating manner in which clean coal is progressively skimmed from surface



Colliery Engineering

Static Dry Washer at Thornley Colliery, 1934

A - An ongoing process of technological progress in coal use

- Following path determined by earlier successes **+ evolving policy drivers**
  - The IEA's three E's of energy policy: Economic efficiency, Energy security and Environmental sustainability.
  - Coal is low cost, most widely available yet least clean fossil fuel wrt local, regional + now global environmental issues
- Technology emphasis therefore also evolving
  - More efficient use
  - Cleaner use
  - More efficient use
  - **Carbon Capture and Storage**

Clean coal technologies

- Cleaner use
  - From coal washing, advanced combustion technologies through to end-of-pipe cleanup
  - *Substantial progress although costs mean BAT not uniformly applied, also emerging issues eg. heavy metals*
- More efficient use
  - Fuel preparation (eg. Drying, in-situ UCG), advanced combustion (eg. USC, IGCC, UCC)
  - *Economic + environmental drivers*
- **Reduced emissions – *now the primary driver***
  - Efficient use – currently our primary means for this
  - Co-firing with renewables, Methane capture from operations
  - **Carbon Capture + Storage (CCS)**

The climate policy challenge

- avoiding dangerous climate change likely to require *major* (60 - 80% from present levels) *rapid* (peaking within 30 years) + *then sustained* (centuries or more) reduction in global emissions
- nearly all reductions have to come from < fossil fuel emissions
- range of proven options for reducing energy-related emissions through **lower emission fossil fuel technologies**, end-use efficiency, cogeneration + renewable energy supply
- infrastructure and major capital investment by far most important decisions that policies need to target
- technical innovation essential as present technology options almost certainly inadequate for scale of change required + promising new technologies continue to emerge
- such transitions in infrastructure and technical innovation have important time lags + therefore require urgent attention

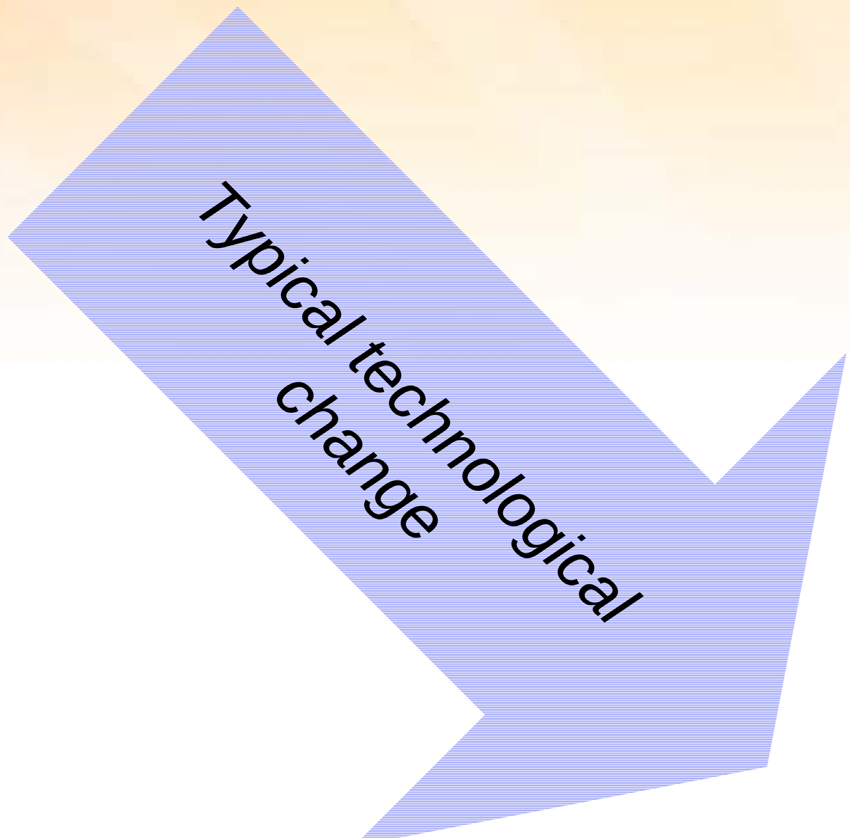
Some dimensions of technological change

Technology *(IIASA)*

'hardware' + 'software' + 'orgware'

Technological innovation

Invention
↓
Commercial-isation
↓
Diffusion/ adoption



What drives technological change

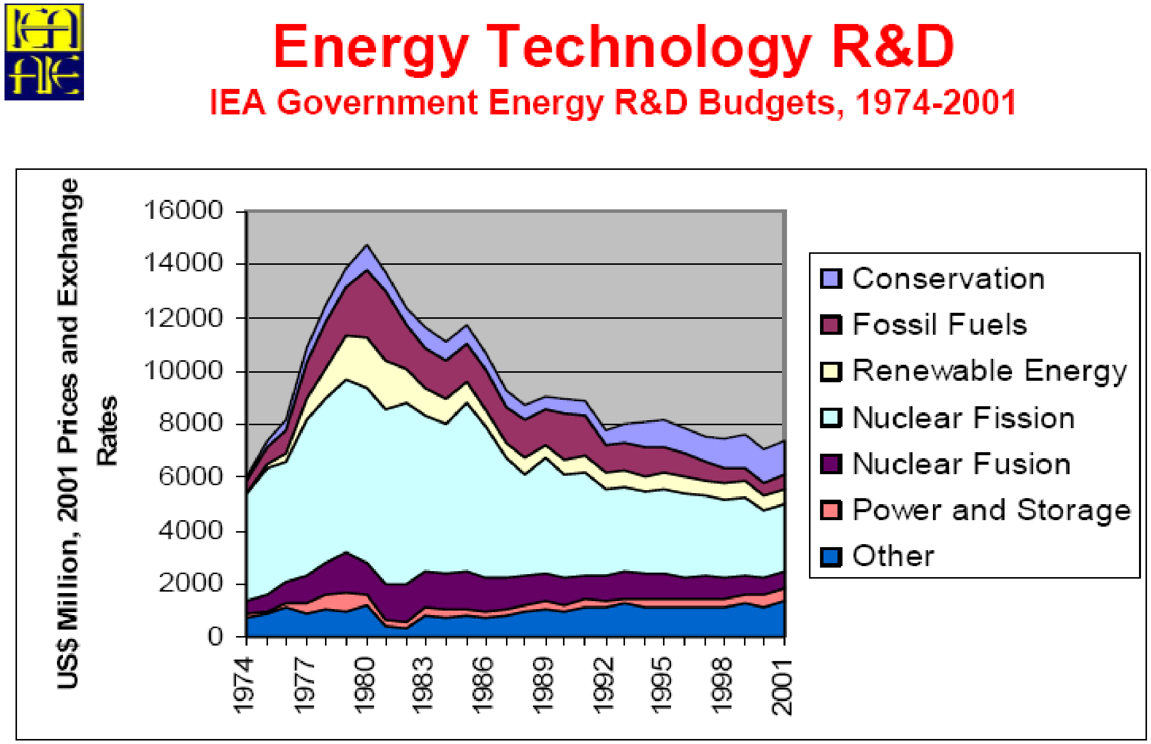
- Markets, and their competitive pressures *(market pull)*
  - but these currently have severe climate *externality* failings, generally under-deliver R&D, more systemic problems too..
- Technology 'champions' *(largely R&D push)*
  - But dangers of undue techno-optimism + unaccountable elites
- Government policy efforts: important roles in:
  - *Invention*: support R&D into promising socially beneficial yet unproven technologies *(R&D push)*
  - *Commercialisation*: support demonstration + initial deployment of promising but tech. proven, technologies *(mostly push)*
  - *Diffusion/Adoption:* ensure markets reflect societal preferences (make markets reflect societal preferences, 'niche' market pull)
- *In the end, successful change comes from societal preference => its really about social choice… hopefully informed*

R&D + commercialisation of energy technologies

- Govt role because private firms likely to underinvest
  - Energy industry R&D < 10% of overall industry average
- R&D relatively low cost but high risk, potentially very high returns
- Demonstration higher cost but less risk - *Demonstration is not deployment – results necessarily experimental b/c trying new approaches* *(Watson et al., 2001)*

- **Australia** - $223m in 2001-2 on energy sector innovation ~ 5% science + innovation budget

- *Public funding necessarily directed to particular technologies – who and how is assessment of priorities to be done?*



Diffusion/adoption of energy technologies

- Govt role b/c many markets don't reflect societal prefs:
  - Energy different from key areas where major innovation has been market driven (eg. IT + Telecoms) – driven by concern, not opportunity
  - Externalities + adverse subsidies, systemic challenges, infrastructure, technological/institutional lock-in

=> Governments can create niche mkts, transform existing mkts

  - Some potential to avoid choosing technology focus (eg. Emissions Trading Schemes) *however* limits because niche markets are 'designed'
  - **Australia:** examples incl. MRET, Qld 13% Gas, LPG excise exemptions

- *Many effective programs require technology focus – who + how*

Guidance for policy makers

- Uncertainties in innovation mean risks in *picking winners*
  - Governments often pick losers
  - Even if chosen technology eventually succeeds to some extent, support may have been far better spent elsewhere
- *Yet*, limited public resources require prioritisation

Valuable formal risk management strategies include
diversification – a portfolio approach
flexibility – choices that don't preclude other choices later

However, priorities still have to be established *(its not enough to say everything should be supported)*

=> important role for **risk-based technology assessments**

Technology assessment for greenhouse options

- A range of abatement options, of varied status + promise
  - *Improved end-use energy efficiency*
  - *Renewable technologies*
  - *Lower emission fossil fuel technologies* – eg. CCGT, CHP
  - ***Clean Coal including Carbon Capture + Storage***

=> possible risk-based technology assessment framework
  - *Technical status* – unproven => mature, emerging => widespread
  - *Delivered services and benefits* – **GHG emission reductions**, flexibility, others… eg. dispatchability, network requirements
  - *Present costs* where known, and possible future costs
  - *Potential scale of abatement* – possible technical + cost constraints
  - *Potential speed of deployment*
  - *Other possible societal outcomes* – eg. other env. impacts, energy security, economic development + prospects

Preliminary assessment – technical status

Lower emm fossil-fuel techs	CCGT mature + widely deployed, larger CHP mature Proven USC coal plant, demonstrated IGCC, other technologies show promise
Carbon Capture + Storage	CO2 capture commercial in oil + chem. industries, coal-fired generation may require ‘advanced’ pre-commercial IGCC eg. FutureGen ‘new’ CO2 storage not yet demonstrated, although some injection underway, with experience in EOR, limited experience with ECBM + saline aquifers. Considerable R&D + demonstration now underway *but proving injection = storage may take decades*

Preliminary assessment – delivered services

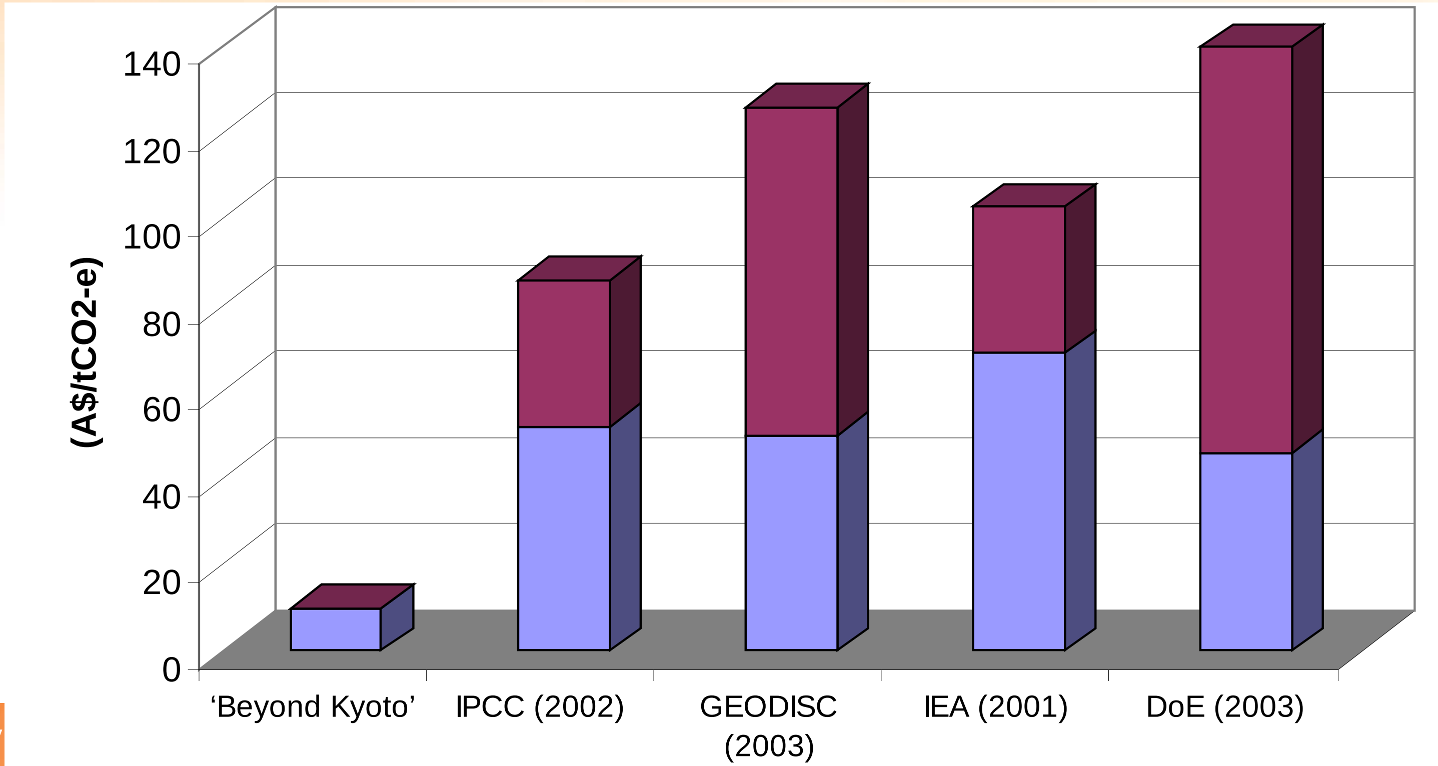
Lower emm fossil-fuel techs	CCGT emissions approx. ½ of coal plant, good fit with existing centralised infrastructure, CHP has distributed benefits Limited abatement opportunities with advanced coal generation, a range of other env. impacts although useful clean-up technologies available
Carbon Capture + Storage	IGCC+CCS offers potential 1/5 emissions of current coal plant but long-term storage needs to be proved, good fit with existing centralised infrastructure, possible value adding through EOR + ECBM

Preliminary assessment – costs.. now + future

Lower emm fossil-fuel techs	Costs of gas plant very dependent on gas prices – not cost competitive for baseload in Australia Advanced coal combustion technologies not competitive with super-critical units at present, ongoing technical progress can reduce costs
Carbon Capture + Storage	Gas project costs may be quite low, CCS for generation has highly uncertain + potentially variable costs depending on capture + sequestration. Some potential for cost reductions with learning (as with many emerging technologies)

Possible CCS Costs

- Many challenges in cost estimations … particularly for technology systems that don't yet exist
  - technology not yet demonstrated integrated + at scale
  - some methodological choice critical, eg. NPV vs Levelised
  - can be very project specific

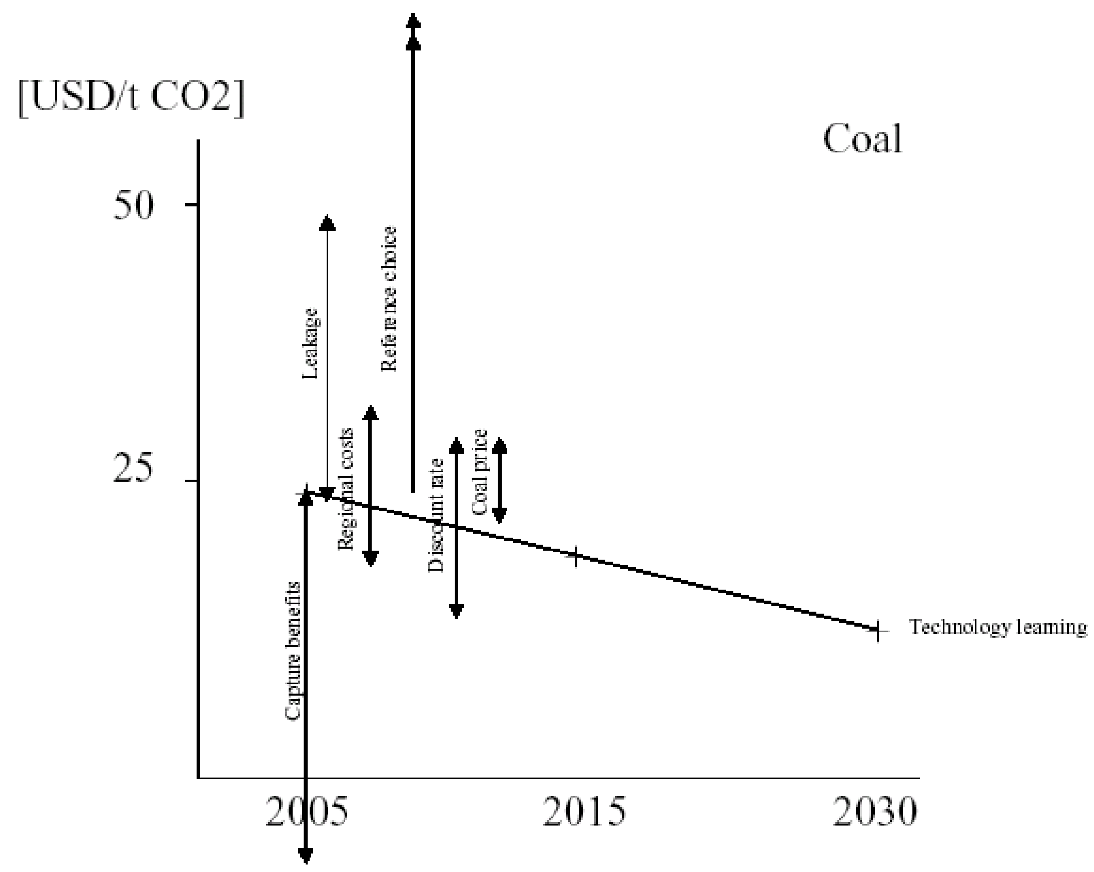


CCS costs: …into the future

- ‘learning’ effects outweighed by present uncertainties

  eg. range of CO_2 *capture* costs for coal fired power plants

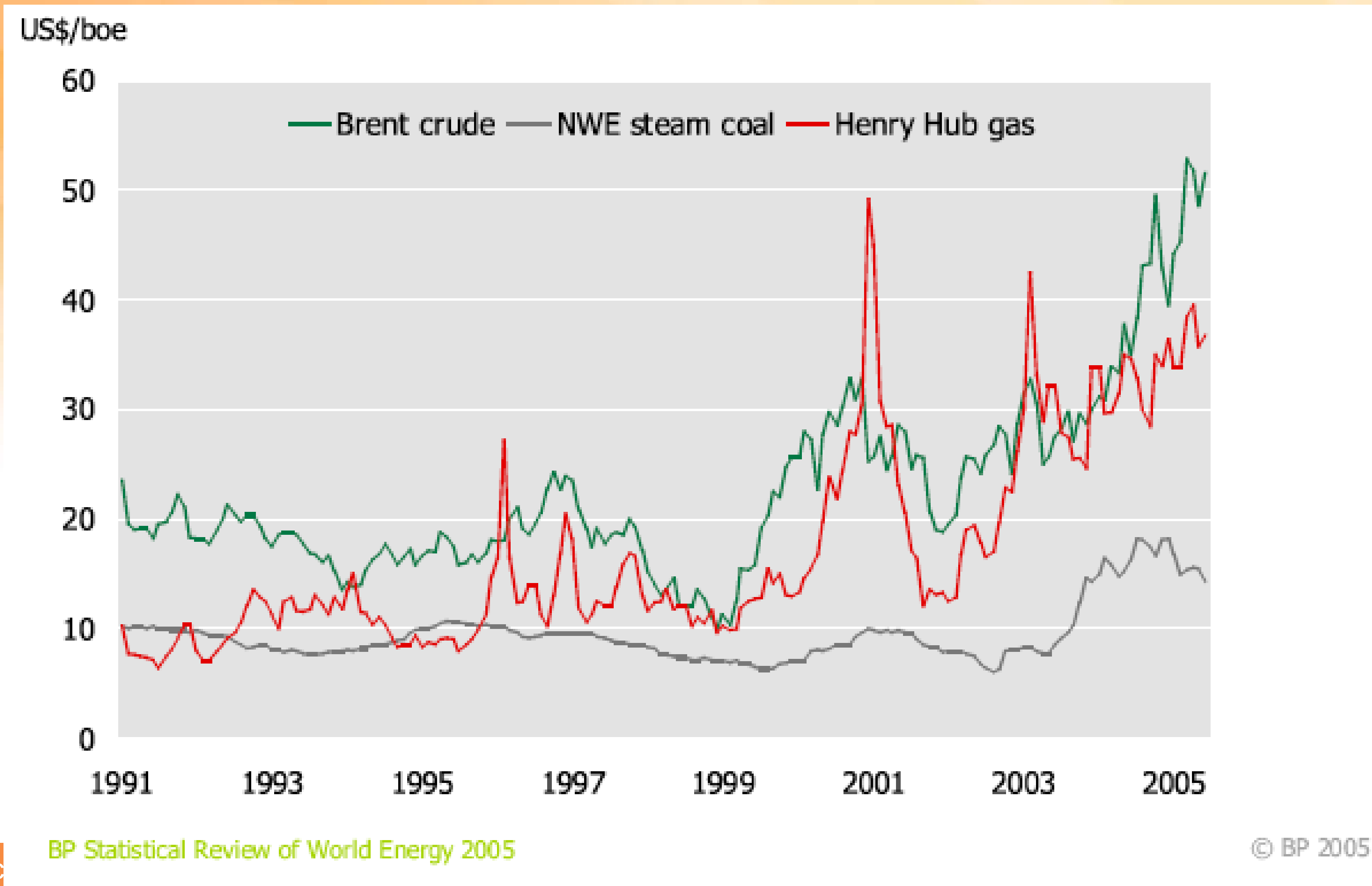
Gielsen (2003)



- **And technologies compete..**

  “while renewable energy technologies have failed to meet many early projections of *market penetration*, they surpassed most *cost* goals. The answer to the riddle is that the target has moved: the cost of generating energy from competing sources has dropped farther and faster.” *Resources for the Future, 1999.*

…. competition depends on energy prices (BP 2005)



Preliminary assessment – potential scale

Lower emm fossil-fuel techs	Potential for CCGT driven by likely available gas supplies (possible issues in Eastern Australia), CHP has high penetrations (40%) in some countries Coal currently generates ~80% of Australian electricity, very large reserves available
Carbon Capture + Storage	Potentially very large, although difficult to estimate given present uncertainties on long-term storage – particularly in saline aquifers Some Australian states may not have much storage available (eg. NSW)

Preliminary estimates of CCS abatement potential in Australia

GEODISC

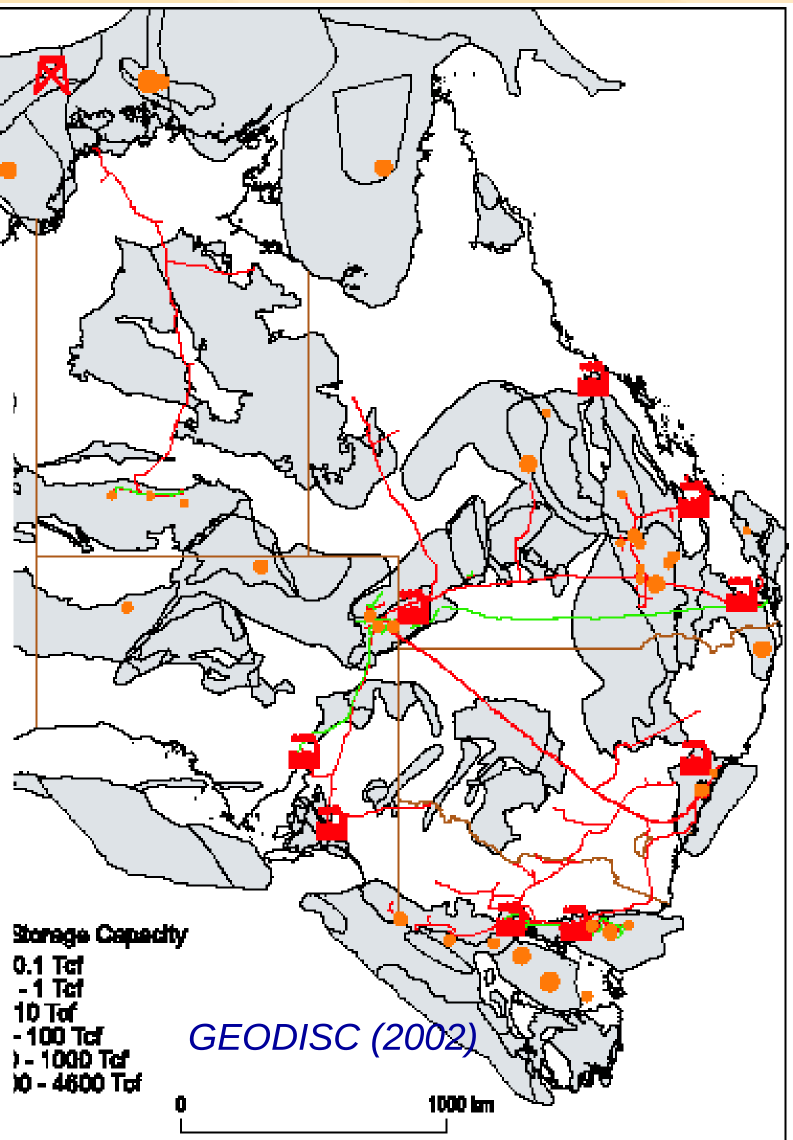
Very large potential resource (1600 years of present emissions)

But, most identified potential storage in the North-west (yet most emissions in South East)

Around 95% is saline acquifer

Very limited EOR, Coal Seam opportunities => saline storage the only realistic option for significant abatement (IEA, 2003)

Still, GEODISC estimates 50-70% of stationary energy sector emissions might be *sequestered* at US$50/t$CO_2$



Gas pipeline

GEODISC (2002)

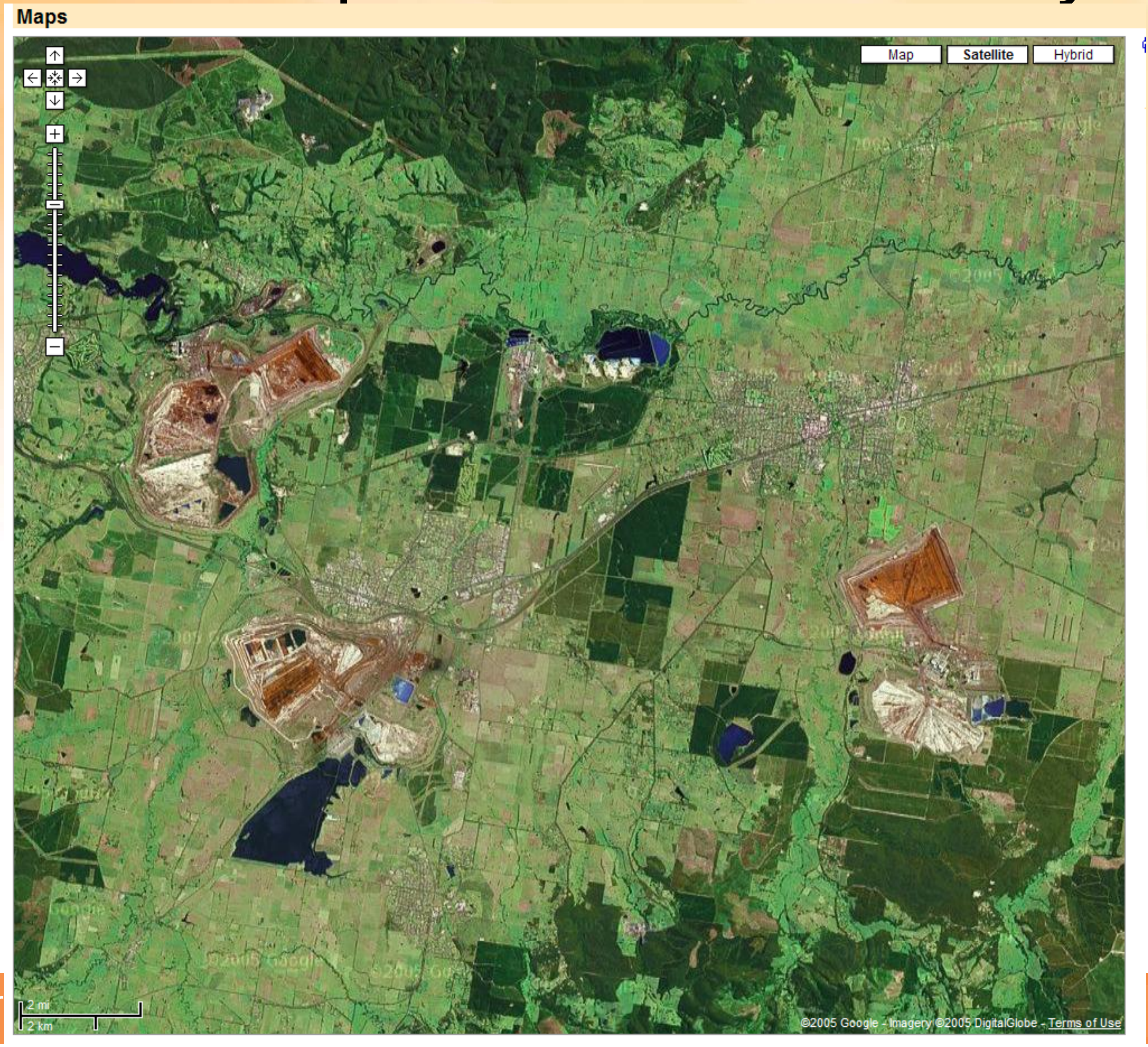
Preliminary assessment –speed of deployment

Lower emm fossil-fuel techs	Very fast for proven mature technologies. CHP uptake potentially slowed by existing institutional barriers.
Carbon Capture + Storage	Appears possible now for gas projects eg. Gorgon. CCS for coal generation still has to be demonstrated, then commercialised. Integration, application + scale may take decades. Proving injection = storage may take decades or more + may be site specific - creates risks for deployment

Preliminary assessment – other societal outcomes

Lower emm fossil-fuel techs	A range of direct air, water + land env. impacts with fossil fuels. Energy security a possible issue with gas for many countries, coal with some countries. Many existing + emerging clean coal technologies to address some of these. Coal an important contributor to Australian economy (both export + low cost energy supply) + offers high energy security
Carbon Capture + Storage	Direct env. risks from sudden or slow escape of CO2 to atmosphere or ground waters. May allow continued use of fossil-fuels

Example: Land-use impacts in Latrobe Valley



Clear rationale to support ‘clean coal’

- Many international programs
  - US DoE – Clean Coal Technology Program
  - UK DTI – *Cleaner* Coal Technology Programme
  - EU, other nations who sell and/or use coal
- Australia
  - Many efforts – Federal + State, private players too

CO2 CRC COOPERATIVE RESEARCH CENTRE FOR GREENHOUSE GAS TECHNOLOGIES
Reducing carbon dioxide emissions to the atmosphere

CCSD Cooperative Research Centre for
Coal in Sustainable Development
>Contacts >Site Map >Search

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CLEAN POWER FROM LIGNITE

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Lessons from earlier US DoE CCT Program

- President Bush has proposed $2 billion in new coal subsidies on top of the $2 billion already squandered on the Clean Coal Technologies program, which has been plagued by mismanagement and overruns. … these efforts have not borne fruit, and have largely been financial and technological failures.
  WWF, COAL: America's Past, America's Future?, 2001
- "Environmental Control and Coal Preparation technologies, even when successful, were not competitive with conventional scrubbing or switching to low-sulfur coal, and none were directed to the problem of CO2 emissions. The Advanced Power Generation technologies, including fluidized bed and IGCC, could not compete with gas-fired combined cycle with natural gas prices as low as they were."

  CRS Report for Congress on the DOE Clean Coal Technology Program, 2001.
- "Nevertheless, this program serves as an example to other cost-share programs in demonstrating how the government and the private sector can work effectively together to develop and demonstrate new technologies."
  US General Accounting Office, 2001
- "Realised economic benefits of DOE fossil energy programs from 1978-86 less than costs of programs ($3.4b vs $6b). Those from 1986-2000 were $7.4b vs $4.5b expended. Also, valuable environmental benefits and "A number of technologies have been developed that provide options for the future if economic or environmental concerns justify their use. For example, …IGCC"
  The National Academies, Energy Research at DOE: Was it Worth It?, 2001.

Federal Government technology assessment

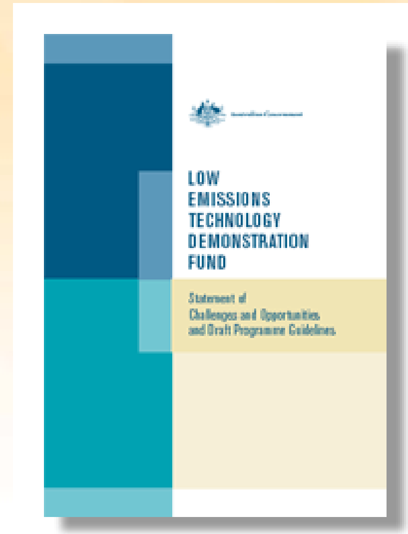
- Not clear what criteria applied, process by which established

Table 2: Technology assessments

Market leader	Fast follower	Reserve
Play a leading role in international R&D efforts.	Strongly position Australia to follow international developments quickly.	Position Australia to monitor international developments and follow as needed.
Energy supply technologies		
Advanced brown coal Geosequestration Hot dry rocks Photovoltaics Remote area power systems Coal mining and extraction	Advanced black coal Natural gas Wind Biomass Wave	Hydrogen Tidal Large-scale hydro Nuclear
Energy demand technologies		
Solid Oxide Fuel Cells	Intelligent transport systems Energy efficiency Advanced conventional vehicles Hybrid electric vehicles	Other fuel cells

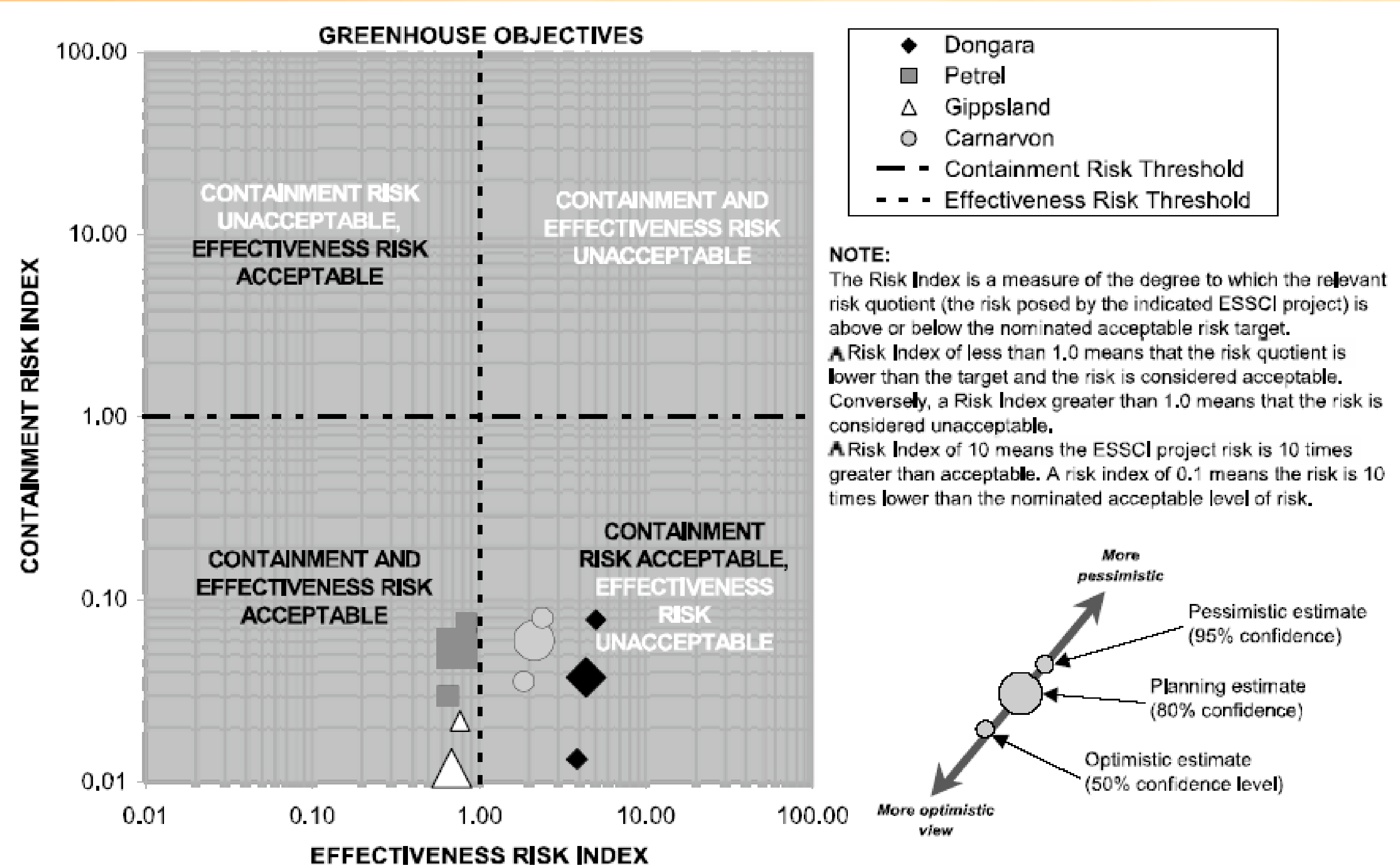
More specific technology assessments

- LETF Draft Merit Criteria
  - Potential of technology to lower Australian energy sector's greenhouse gas emissions signature from 2030
  - Technical feasibility, readiness for demonstration
  - Value for money
  - Management capability
  - Extent project likely to provide additional national benefits for economy, society + environment



More specific risk-based technology assessments..

- Bowden and Rigg, ASSESSING RESERVOIR PERFORMANCE RISK IN CO2 STORAGE PROJECTS, CO2CRC, 2004



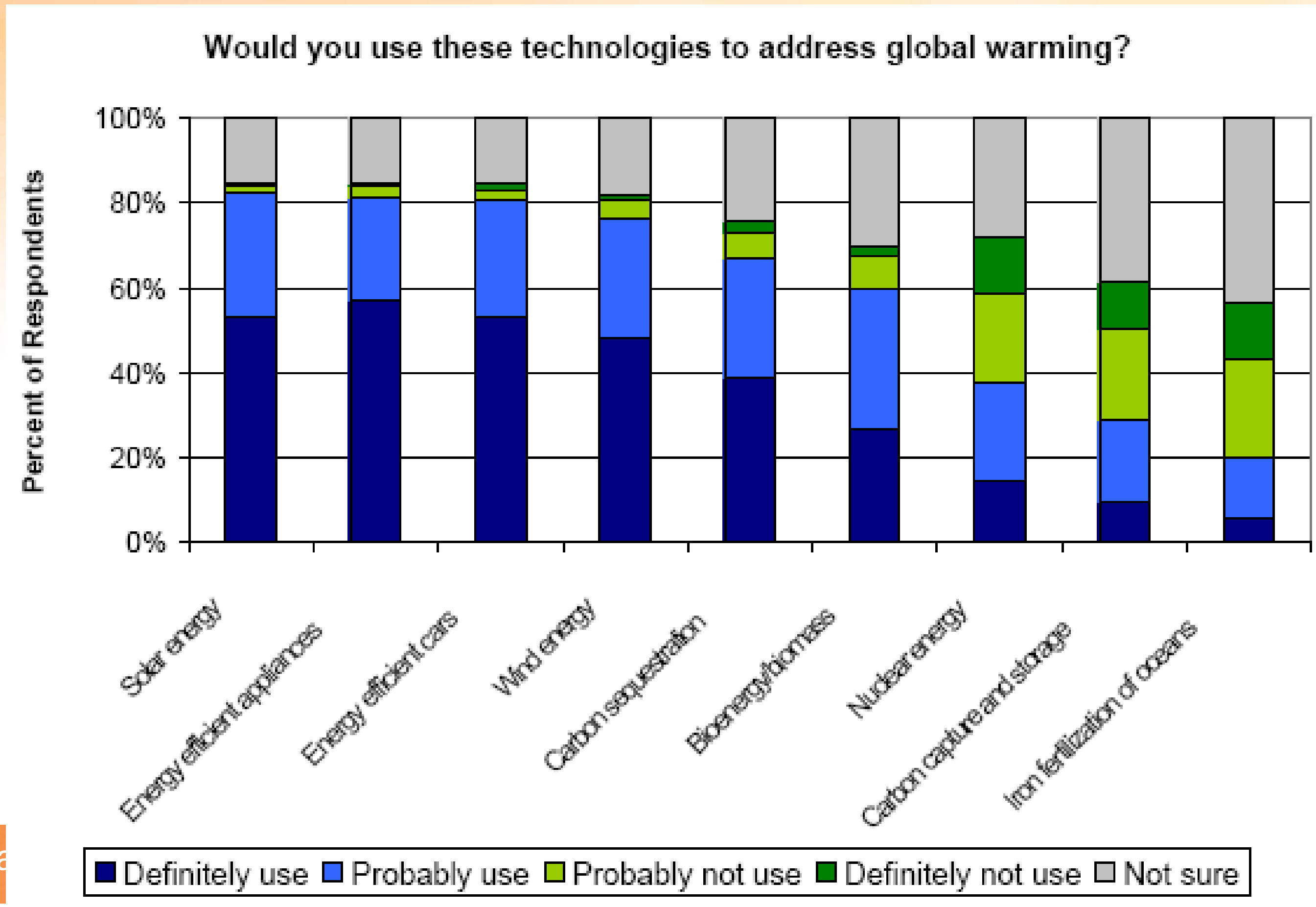
Some thoughts on Australian energy policy

- **Lacking coherent abatement + innovation strategy**
  - **Energy White Paper** focuses largely on technological push (eg. innovation funds), rather than market pull (eg. ETS, 'niche' markets)
  - *This is very unlikely to be optimal policy approach*
    - "Australia's focus on technological solutions to climate change has certain advantages. Although it carries the risk that technological solutions will not be forthcoming, it also recognises the long-term nature of this issue and the need for massive changes in energy patterns that new technologies can achieve. However, even if such technologies are found … a carbon price signal will probably still be needed to facilitate their implementation."
      IEA, Energy Policies of IEA Countries: Australia Review, 2005
  - Clean Coal + all other energy technologies have associated risks
    - Can be categorised as "social experiments" + this requires informed consent
    - Open + transparent technology assessment process is key

The public currently poorly informed + sceptical

– Far more supportive of CCS if part of portfolio of climate change actions including energy efficiency + renewables

Cambridge/MIT Study of US public views on climate change, 2004



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